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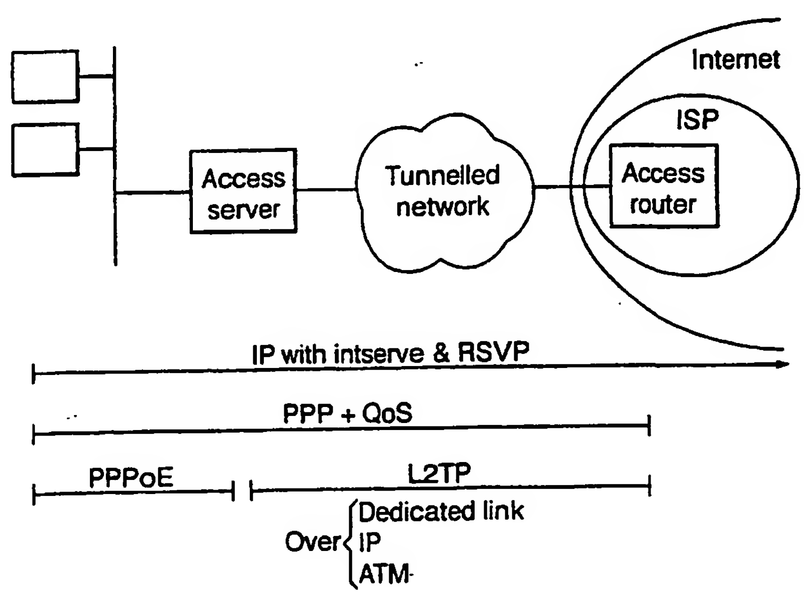

(57) Abstract: A network arrangement involving three networks - one between one or more user-hosts and an access server, one between the access server and one or more access routers associated with one or more ISPs and a third, which may be the Internet, accessible via the routers and in which the first network is a shared-media network and/or information packets are multiplexed over one or more tunnels in the second network - employs PPP as an access-network protocol and as a service-access protocol between the hosts and the access routers, and equips the PPP access-network protocol with an independent QoS capability. The first network may be an Ethernet running under PPPoE protocol, or it may run under ATM linking to an L2TP Access Concentrator. .

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

NETWORK ARRANGEMENT

The invention relates to a network arrangement having first, second and third networks, one or more hosts connected to the first network, an access server for linking the first and second networks and one or more access routers for linking the second and third networks.

The Internet has, in recent years, assumed greater and greater importance as business- and residential users have demanded access to information of all types, including not only text but also images and, as a further sophistication, sound and video. Such access has been facilitated by the development of a particular network communications protocol, namely the AInternet Protocol≅ (IP).

IP is capable of transferring all these disparate forms of communication over the same network infrastructure and allows video and other forms of communications to share the same bandwidth. However, if fair exploitation of the available bandwidth is to be assured among the various services mentioned, special attention must be directed toward the matter of Quality of Service (QoS) and in particular how QoS is defined and delivered.

The three main role-players in the delivery of an IP service are the customer, the Network Access Provider and the Service Provider. A network model incorporating these players is illustrated in Figure 1, which shows the customer=s equipment (e.g. a PC) as reference numeral 10, the Access Network as reference numeral 12 and a series of different Internet Service Providers (ISPs) as reference numerals 14. The ISPs maintain Access Routers (not shown) which link up with the Internet 16. The customer

cannot connect directly with the Internet, but must go through the Access Network first, and this then provides him with a transport channel to the ISP of his choice. Once he is linked to the ISP via such a channel, he can then request the service that he requires from the ISP.

The network model, as can be seen from Figure 1, includes a selection protocol between the customer and the Access Network to set up the transport channel; an access network protocol representing the transport channel between the customer and the service provider, and a service access protocol between the customer and the service provider. The service access protocol is supported by the access network protocol.

An example of an actual architecture typifying this model is shown in Figure 2 and is based on the present-day PSTN (Public Switched Telephone Network) system. In this architecture, the customer equipment (Customer Premises Equipment, CPE 20) may be a series of PCs connected via respective modems 22 to the PSTN network 24, which represents the Access Network. A series of Service Providers 26 are accessible via the PSTN system via a pool of modems 28 at the ISP-end. In this embodiment, the selection protocol of Figure 1 is represented by the PSTN dialling facility, the access network protocol is represented by the telephone switched circuit linking the modems 22 and 28 and the service access protocol is represented by the PPP (point to point) protocol.

The telephone circuit provides a guaranteed 64 Kbps data channel, which is possibly slightly reduced by modem technology. As the PPP session has a one-to-one relationship with the telephone circuit, it inherits its QoS. The QoS class provided by the PSTN is forced and cannot be specified in the selection protocol. In addition, the PSTN

system is essentially a narrowband system and inherently, therefore, ill-suited to the kind of service convergence mentioned at the beginning.

There is, then, a need for a high-speed (broadband) Access Network and this need can be met to a limited degree by the so-called ATM SVC-based system (Asynchronous Transfer Mode Switched Virtual Circuit), which was designed to allow great flexibility in the QoS parameters to be contracted to by the user. Such an arrangement is depicted in Figure 3, in which an ATM network 30, based on a number of ATM switching devices 32, stands between the CPE 34 and the various ISP access routers 36. In this case the selection protocol is constituted by the ATM user signalling, the access network protocol by the ATM connection itself and the service access protocol by, again, PPP. All the ATM features are available from the customer premises to the ISP via the access network, so that the customer is provided with QoS guarantees for different classes of service all the way from his end (source-end) to the destination-end. In practice, the desired QoS parameters are sent by the user along with the address of the desired end-point over the UNI (user-network interface) to the switch 32.

As in the PSTN example, there is a one-to-one relationship between the PPP sessions and the ATM calls, which allows the PPP sessions to inherit the QoS defined in ATM. Since the ATM infrastructure makes the provisioning and configuration of QoS an easy matter, ATM would appear to be a very attractive choice, given the requirements presented earlier. However, there is a problem in as much as the use of ATM is not very widespread at present. Far more prevalent than the use of ATM network equipment is the use of Ethernet equipment, so that in practice, whatever the virtues of the ATM-based system, it would be desirable to concentrate on an Ethernet-based arrangement if the best and most economic use of existing equipment is to be made.

In accordance with the invention, there is provided a network arrangement comprising a first (40, 46; 82, 83), a second (50, 88) and a third (87) network; one or more hosts (42) connected to the first network; an access server (48, 84) for linking the first and second networks and one or more access routers (52, 86) for linking the second and third networks, in which

- information packets are multiplexed over one or more tunnels (54, 90) in the second network;
- PPP is employed as an access-network protocol and as a service-access protocol between the one or more hosts and the one or more access routers, and

- the PPP access-network protocol is provided with an independent QoS capability.

The first network may include an Ethernet network configured to operate under PPPoE.

The access server is preferably provided with the following functions:

- admission control, for checking on the availability of resources requested at the host-end of the network arrangement;

- classification, for associating packet frames with their particular communication sessions;

- policy enforcement, for preventing host-users from using more resources than agreed following the request for resources,

- scheduling, for allocating priority to packet frames in accordance with a contract entered into by the host-users.

One or more tags employed during a discovery phase of the PPPoE protocol may be provided with information relevant to the requesting of desired QoS parameters. The tags may be Service_Name tags.

An L2TP protocol may be used between the access server and the one or more access routers.

The first network may include an access network (83), the access server may be a LAC access server (84), the access network may communicate with the access server using ATM and the access server and the third network (87) may communicate over tunnels (90).

Signalling of QoS requirements may be effected during an authentication phase of the PPP protocol.

Embodiments of the invention will now be described, by way of example only, with reference to the drawings, of which:

Figure 1 is diagram of a network-architecture model;

Figure 2 shows the model of Figure 1 incorporating a PSTN architecture;

Figure 3 shows the model of Figure 1 incorporating an ATM architecture;

Figure 4 is a diagram of a network model for PPP over Ethernet;

Figure 5 is a block diagram showing the functions of a network arrangement in accordance with a first embodiment of the invention;

Figure 6 shows a PPPoE-based network architecture in accordance with the first embodiment;

Figure 7 shows an Ethernet LAN in one scenario in connection with the possibility of the need for QoS functioning at the Ethernet layer in relation to the first embodiment, and

Figure 8 shows an ATM-based network architecture in accordance with a second embodiment of the invention.

A first embodiment of a network arrangement according to the invention employs the so-called APPP over Ethernet≅ (PPPoE) protocol, a reference model for which is shown in Figure 4. In this model an Ethernet LAN 40, comprising the commonly used bus-type structure connected to a series of CPE devices, or Aclients≅ 42, is connected via a Network Terminal (NT) 44 and a bridge-transport network 46 to a PPPoE server 48, which performs the function of an Access Server, as described above. The server 48, which can be termed a PPP switch, communicates across a network 50 to the Access

Routers 52 of a number of ISPs. The network 50 conveys the message packets through so-called Atunnels≅ 54 using as a protocol the L2TP (Layer 2 Tunnelling Protocol). Tunnelling is a process whereby packets are Aencapsulated≅ in the PPP switch 48 before entering the network 50 and unpacked at the other end by the Access Routers 52, the original addressing and data information remaining unchanged. Thus the mode of transport of the original packet-information is transparent to the user.

The advantage of the use of PPPoE is that, where the physical Ethernet interface is already in place, all that needs to be added is a PPPoE client (a driver that is simply added to a PC, for example). Also, a very simple modem is all that is required at the user end to bridge the Ethernet frames received from the user to the Access Server 48 over the ATM-based access network. The Access Server 48 interprets the PPPoE protocol and conveys the PPP session to the ISP chosen by the user.

Note that there is no customer-to-ISP protocol employed other than PPP, so that PPP has the role of both access network protocol and service access protocol, as opposed to merely the service access protocol as in the PSTN and ATM-SVC arrangements described earlier. Also the PPPoE protocol is sufficiently rich and flexible to perform all the functions of a selection protocol.

The PPP switch is the flexibility point of the Access Network. It switches the PPP sessions towards their respective chosen ISPs, treating the PPP protocol as an access network protocol and not as a service access protocol. (The latter should transparently cross all the access network components, including the access-network protocol switches). The choice of L2TP as the tunnelling protocol not only allows the

tunnelling process to take place, but also provides a multiplexing function which allows multiple PPP sessions to use the same tunnel.

In such a situation where PPP is being used over a shared medium (such as Ethernet) or is being multiplexed over a tunnel (in the present scenario both are taking place), the invention provides for the PPP protocol to have its own QoS capabilities in order to cater for the variable demands on resources made by the users of the system. This was not needed within the previously described PSTN and ATM scenarios, since there the PPP simply inherited the inherent QoS capability of the underlying access network protocols. To provide this QoS capability, the present invention equips the PPP network elements, i.e. in the case of the Figure 4 scheme the switch 48, with the following functions:

(1) Admission control - when a request for particular resources is made, the availability of these resources is checked and, if the result of the check is negative, the request may be refused.

(2) Classification - packet frames are tied together with the particular session or Aflow≡ that they belong to.

(3) Policy enforcement - access-network users are prevented from using more resources than initially agreed upon in their requests.

(4) Scheduling - specific priorities are given to frames in accordance with contracts entered into by the access-network users.

This arrangement is illustrated in Figure 5. In Figure 5 the PPP sessions are associated with specific QoS parameters via a signalling protocol 60 (to be described

later) or by a management system via a management channel 62. An admission control function 64 checks the availability of the requested resources to see if those parameters can be guaranteed. The PPP frames are associated with their respective sessions in the classifier 66 which, in the PPPoE architecture being used here, can discriminate between the sessions using a session identifier field. The scheduler 68 serves the different PPP sessions according to their QoS parameter and may be very complex, depending on the granularity of the QoS parameters and the fairness of the service. ("Granularity" here is used to mean the number of possible packet flows, each having a different QoS characteristic). Possible implementations of the scheduling function are, e.g.: priority FIFO (First In, First Out), WFQ (Weighted Fair Queuing) and $(WF)^2Q$ (Worst-Case Fair-Weighted Fair Queuing). Finally, the policing function shown in block 70 interacts with the scheduling function 68 to cause frames which exceed the contracted-for resources to be either discarded or marked Alow priority≅.

At the same time as the above functions need to be assigned to the PPP switch, changes need to be made to the PPPoE protocol in order to implement these functions. In this embodiment of the invention use is made of a tag present in the so-called Adiscovery phase≅ of the PPPoE protocol to convey the requisite QoS information.

PPPoE has two separate phases: a Adiscovery phase≅ and a Asession phase≅. In order to initiate a PPPoE session, a host must perform discovery to identify the Ethernet MAC (Media Access Control) address of the access server and set up a PPPoE SESSION_ID. Discovery is inherently a client-server relationship, in contrast to PPP which defines a peer-peer relationship. The discovery process is so named because in

this process a host (the Aclient≅) discovers an access server (the Aserver≅). Depending on the network topology, there may be a number of access servers with which the host can communicate. During the discovery phase the host is able to discover all access servers and then select one. At the end of discovery, both the host and the selected access server have the information needed to set up their point-to-point connection over Ethernet. No resources are allocated during the discovery phase until a PPP session is established. Once a PPP session is established, both the host and the access server must allocate the resources for a PPP virtual interface.

The invention uses the afore-mentioned tags present in the discovery phase of the protocol to signal the QoS parameters of the PPP session. The tags are in the form of TLVs (Type-Length-Value segments) with the length expressed by a 16-bit integer, so that a tag may be 64 kbits long. One specific tag which is specified in the PPPoE protocol standard is called AService_Name≅ and the present embodiment of the invention impresses onto this Service_Name tag details of the QoS class required.

In this scenario, PPP frames are policed and served in the same way that IP packets are managed in QoS-enabled routers. PPP sessions are multiplexed over tunnels towards ISPs in the same way that IP packets are multiplexed over datalink (OSI Layer 2) connections. Thus the PPPoE protocol serves as a signalling protocol just as the RSVP (Resource Reservation Protocol) serves as a signalling protocol at the network layer (OSI Layer 3). Following this parallelism, the encoding of QoS parameters into the PPPoE frames should preferably be standardised in the same way as the encoding of IP parameters in RSVP messages is standardised, in order to allow the driver in the PC to

interpret the protocol and map the parameters onto the priority bits of the Ethernet frames. It is also possible to have a proprietary encoding, i.e. one defined by the access-network operator, if that operator supplied the PPPoE driver to the user. In that case the proprietary encoding must be translated into standardised QoS parameters inside the CPE (customer equipment) in order to be properly mapped onto Ethernet priority bits.

A slightly fuller picture of the various protocols employed in this first embodiment of the invention is shown in Figure 6 and includes in the equivalent of the OSI third layer (the Anetwork layer≅) the use of IP in conjunction with IntServ and RSVP to allow the host-user to reserve resources along the route from source to destination. The RSVP-enabled routers appearing along the route schedule and prioritize packets to fulfill the QoS requirements. Then at Layer 2 level ("datalink layer") between the host and the ISP there is PPP with the QoS-enhancement which has just been described. At both Layer 2 and Layer 1 (the Aphysical layer≅) there appears PPPoE between the host and the access server and L2TP between the access server and the ISP.

PPP, then, is supported by the Ethernet protocol at the customer end and by the L2TP protocol at the ISP end. For the admission control process to work correctly, the PPP switch must be aware of the QoS characteristics of these underlying protocols. If either of them is not QoS-capable or provides insufficient QoS, the request made by the user cannot be admitted. In the case of L2TP, it is assumed that this protocol is implemented over a QoS-capable network and that the various tunnels involved have a static and known QoS. If this is so, it is sufficient to insert into the PPP switch information about the tunnels= QoS during the time in which configuration takes place.

Possible QoS-capable arrangements for L2TP are a dedicated point-to-point link or an IP-based or ATM-based network.

As regards the Ethernet part, however, the situation is more complex.

Where an Ethernet LAN caters mainly for, say, residential or SOHO (Small Office, Home Office) users, it can be assumed that it will have sufficient bandwidth to avoid the need for special queuing, or similar, measures. On the other hand, where a LAN experiences heavy traffic, such measures would have to be taken. In this respect it is helpful that the IEEE 802.1p standard defines a set of priority levels that would facilitate the introduction of QoS into the LAN. However, a complete QoS system would also require the inclusion of admission and policy-enforcement functions.

A simple Ethernet scheme avoiding many QoS complications is illustrated in Figure 7. Figure 7 shows an Ethernet LAN 100 connecting several hosts 102 to a PPP switch 104. If it is acknowledged that the critical part of the LAN 100 is the Customer Premises Network, i.e. those portions 106, 108 designated as "private" in Figure 7, then there would be no need to deploy public admission and enforcement mechanisms to guarantee QoS parameters at the Ethernet layer. It can usually be assumed that the Ethernet portion 110 that is shared among several customers 102 is located entirely inside the PPP switch site and supports available bandwidth larger than the sum of the capacity needed by all the customers. On this basis, only the private portions 106, 108 of the Ethernet must be checked against unfair bandwidth allocation, but this is reasonably the responsibility of the owner of the resource.

In contrast to this, a more general scheme should include more complete Ethernet QoS mechanisms. The IETF (Internet Engineering Task Force) is currently standardising how an Ethernet switch needs to interpret the RSVP signalling in order to manage the bandwidth of the Ethernet and provide QoS. This work has led to the development of AA framework for providing Integrated Services over Shared and Switched IEEE 802 Lan Technologies≅ and to the definition, in an Internet draft, of the SBM (Subnet Bandwidth Manager) protocol. SBM is a protocol for RSVP-based admission control over IEEE 802-type (i.e. Ethernet) networks and involves the extraction and interpretation of the signalling information, which is carried by RSVP, by every Ethernet switch it passes across.

The present invention envisages the development of a new framework with characteristics similar to the SBM scheme above in order to preserve the QoS parameters contracted by means of PPPoE. The situation here could be simplified compared with native SBM, as there is a centralised control point (the PPPoE server). If the PPPoE server were provided with the knowledge of the entire Ethernet access network, it would be able to exercise the Admission Control function during a PPPoE discovery phase. In accordance with the required service, an appropriate IEEE 802.1p priority would be assigned to the service.

In a second embodiment of the invention, instead of employing PPPoE as a signalling protocol under PPP enhanced by QoS, as already described, an alternative scheme called the ALAA≅ (L2TP Access Aggregation) scheme is employed. In the LAA scheme (see Figure 8) an ATM permanent virtual circuit (PVC) is established over an

access network 83 between the Network Terminal (NT) 80, which is associated with an Ethernet network 82, and an L2TP Access Concentrator (LAC) 84. The LAC 84 communicates with an L2TP Network Server (LNS) 86, which may be associated with an ISP or a Corporate router, via a backbone 88. The LAC maps PPP sessions within individual PVCs from the access network 83 to PPP sessions in an L2TP tunnel 90 within a single PVC to the selected ISP. If the network provider wishes to exploit its IP network, the tunnel will be established over IP. Thus the LAC provides the operator of the access network 83 with a network concentration point of the individual customer PVCs onto the outgoing (perhaps single) tunnel to the ISP. This significantly reduces the PVC provisioning requirements for operators and ISPs, compared with the establishing of PVCs all the way from customer to ISP.

PPP consists of three main components: a method for encapsulating user datagrams, or frames, this method involving so-called High-Level Data-Link Control (HDLC); a Link-Control Protocol (LCP) to establish, configure and test the data-link connection, and a Network-Control Protocol (NCP) which establishes and configures different network protocols. To select an ISP, the customer-located equipment, CLE, (i.e. a PC or an NT) initiates an LCP negotiation. Once an LCP connection has been established, authentication takes place. During the authentication phase the LAC must identify the user=s targeted ISP. This is done by requiring a Ausername≅ along with a Adomain name≅ to be entered by the user. When the user has been identified, a PPP connection exists between the LAC and the CLE. Next, the PPP session is extended from the CLE to the LNS associated with the chosen ISP. Based on the domain name

provided in the identification phase of the PPP setup, the LAC will determine the destination. Thus, for example, if the user enters AMyName@isp.net≅, the LAC will know that Aisp.net≅ is the destination. The LAC will associate a user=s PPP link with a tunnel and a Call Identifier. The LAC encapsulates the PPP data into L2TP and forwards it across the appropriate tunnel 90 towards Aisp.net≅. The LNS at the ISP-end strips off the L2TP encapsulation and terminates the PPP. An end-to-end PPP connection consequently exists between the user and the LNS. The LNS performs authentication that is appropriate, given the security requirements of the ISP.

In this embodiment, as in the first embodiment dealt with earlier, PPP acts both as the access network protocol and as the service access protocol.

As mentioned earlier, in the CLE the PC and the NT are connected via an Ethernet interface 82. The PPP protocol can be initiated either by the PC or by the NT and several different protocol stacks can be employed to achieve this, including the use of a local L2TP tunnel between host and NT, the use of BMAP (Broadband Modem Access Protocol) and the use of PPP proxy. The local L2TP solution allows the PC to run PPP over L2TP over IP over Ethernet to reach the outgoing NT; BMAP provides a way of mapping ATM over the Ethernet link, and in PPP proxy it is the NT, not the PC, which initiates PPP.

Unlike the situation with PPPoE described earlier, in the LAA scheme there is no authentication and no scheduling in the access server (which in this case is the LAC). While it is possible for the user to request different QoS services (e.g. gold or silver), each service is confined to its own tunnel. Thus all sessions in the same tunnel are

treated the same way. The user can request e.g. a gold service by inputting: "MyName@goldisp.net", following the above example.

CLAIMS

1. A network arrangement comprising a first (40, 46; 82, 83), a second (50, 88) and a third (87) network; one or more hosts (42) connected to the first network; an access server (48, 84) for linking the first and second networks and one or more access routers (52, 86) for linking the second and third networks, in which
   - information packets are multiplexed over one or more tunnels (54, 90) in the second network;
   - PPP is employed as an access-network protocol and as a service-access protocol between the one or more hosts and the one or more access routers, and
   - the PPP access-network protocol is provided with an independent QoS capability.

2. Network arrangement according to Claim 1, in which the first network includes an Ethernet network (40) configured to operate under PPPoE .

3. Network arrangement according to Claim 2, in which the access server (48) is provided with the following functions:
   - admission control, for checking on the availability of resources requested at the host-end of the network arrangement;
   - classification, for associating packet frames with their particular communication sessions;

- policy enforcement, for preventing host-users from using more resources than agreed following the request for resources,
- scheduling, for allocating priority to packet frames in accordance with a contract entered into by the host-users.

4. Network arrangement according to Claim 3, in which one or more tags employed during a discovery phase of the PPPoE protocol are provided with information relevant to the requesting of desired QoS parameters.

5. Network arrangement according to Claim 5, in which the tags are Service_Name tags.

6. Network arrangement according to any one of Claims 2 to 5, in which an L2TP protocol is used between the access server and the one or more access routers.

7. Network arrangement according to Claim 1, in which the first network includes an access network (83), the access server is a LAC access server (84), the access network communicates with the access server using ATM and the access server and the third network (87) communicate over tunnels (90).

8. Network arrangement according to Claim 7, in which signalling of QoS requirements is effected during an authentication phase of the PPP protocol.

Fig.1.

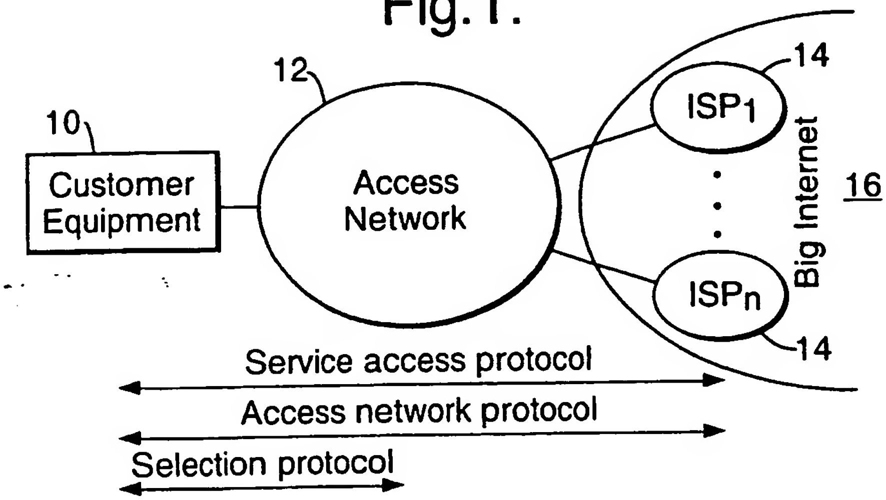
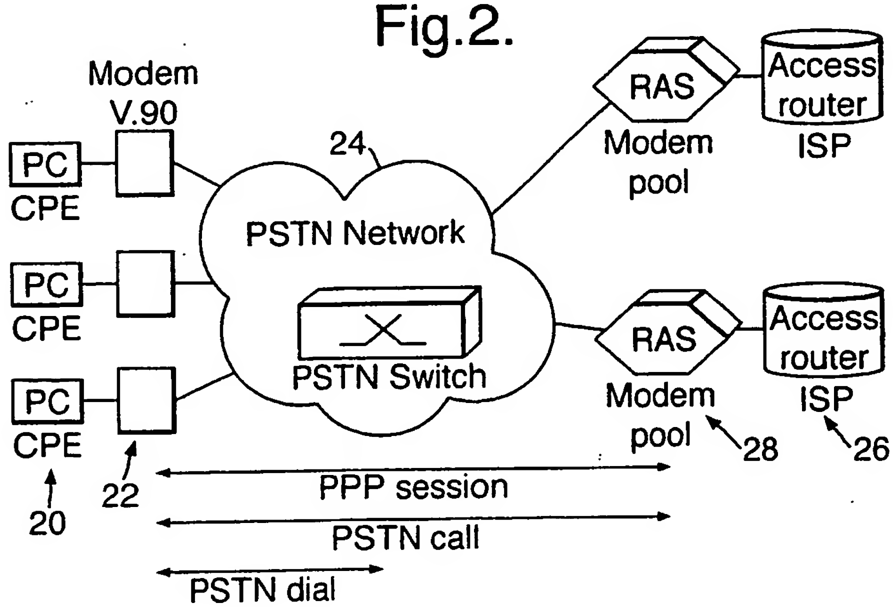

12
10
Customer
Equipment
Access
Network
14
ISP1
ISPn
14
Big Internet
16
Service access protocol
Access network protocol
Selection protocol

Fig.2.


Modem
V.90
PC
CPE
PC
CPE
PC
CPE
20
22
24
PSTN Network
PSTN Switch
RAS
Modem
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Modem
pool
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router
ISP
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PPP session
PSTN call
PSTN dial

Fig.3.

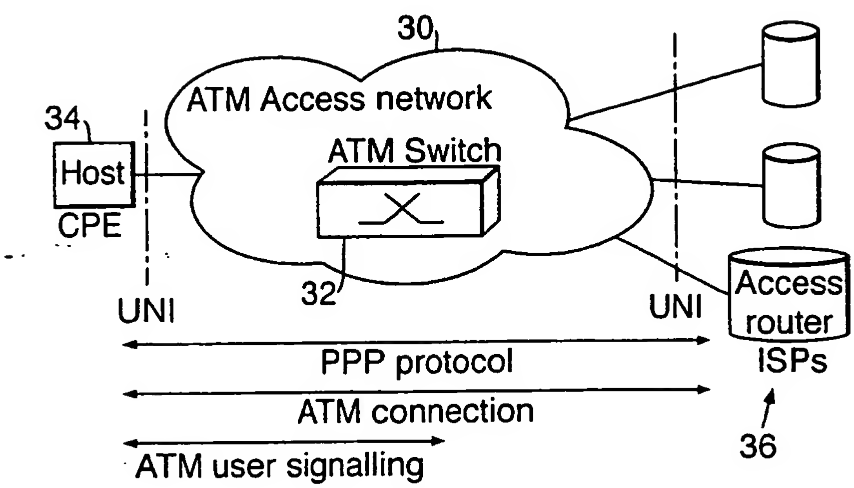
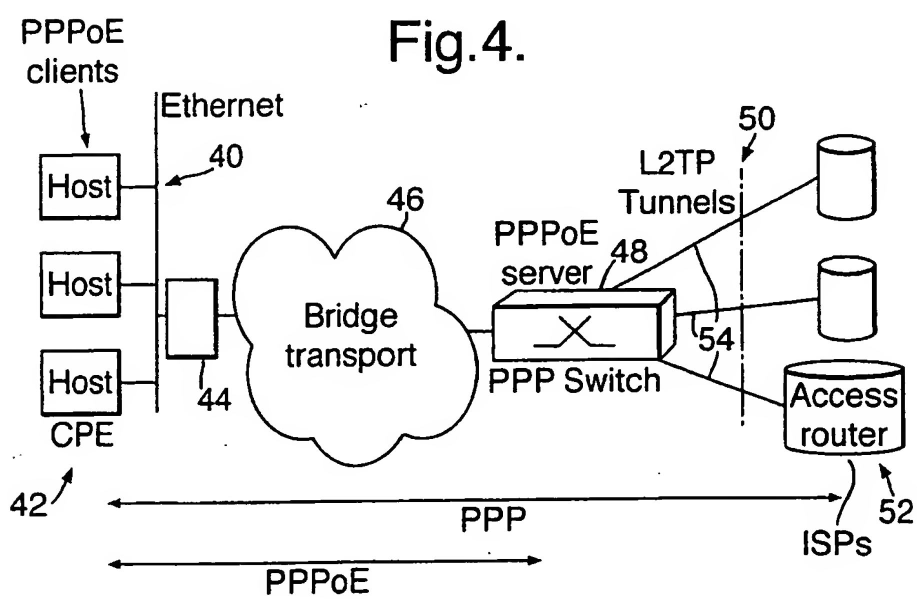

30
ATM Access network
ATM Switch
34
Host
CPE
32
UNI
UNI
Access
router
ISPs
PPP protocol
ATM connection
ATM user signalling
36

Fig.4.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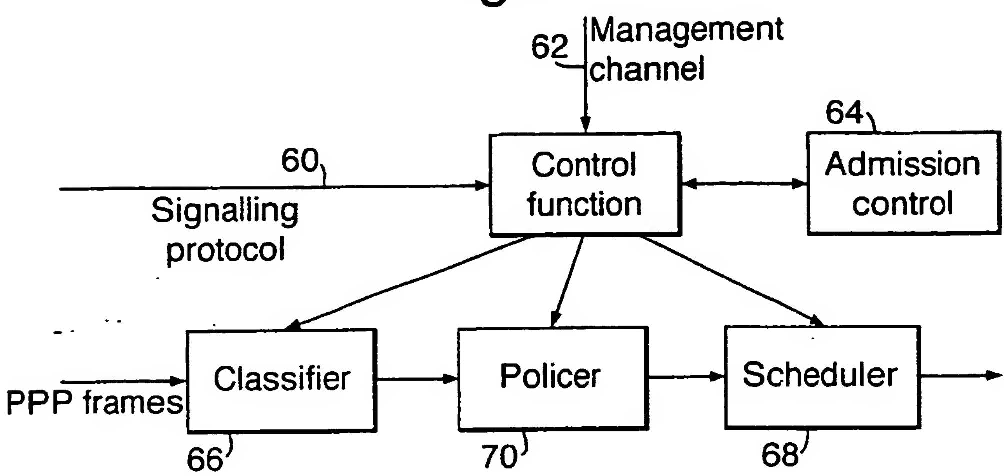
clients
Ethernet
40
Host
Host
Host
CPE
42
44
46
Bridge
transport
50
L2TP
Tunnels
PPPoE
server
48
54
PPP Switch
Access
router
52
ISPs
PPP
PPPoE

Fig.5.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Management
channel
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Admission
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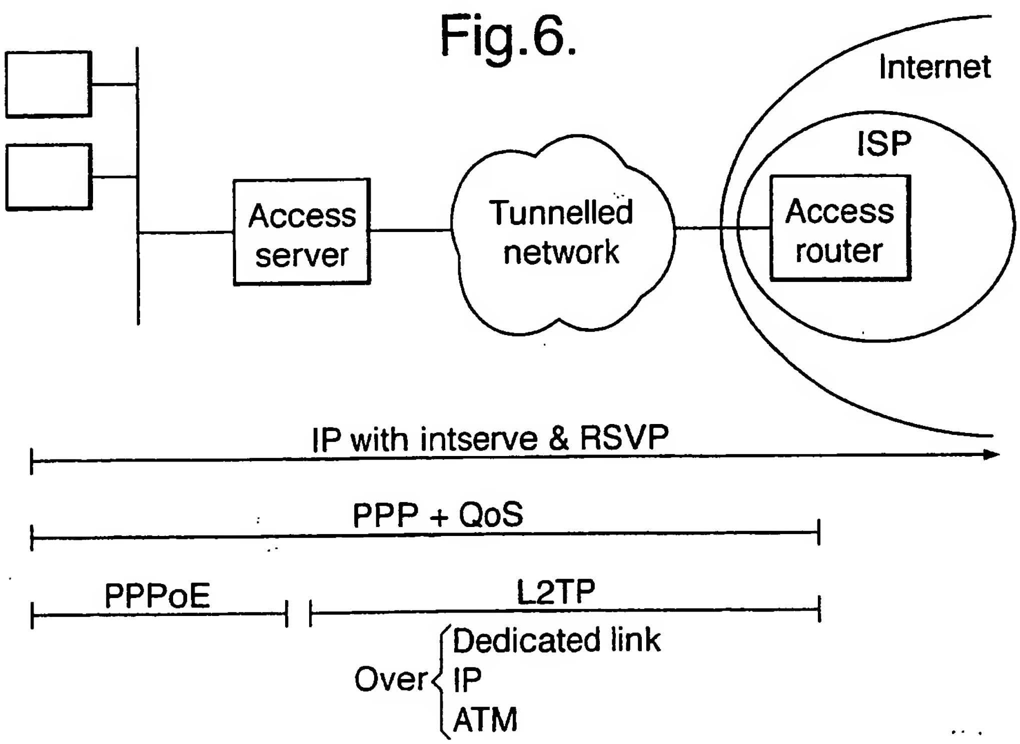
60
Signalling
protocol
Control
function
PPP frames
Classifier
Policer
Scheduler
66
70
68

Fig.6.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Access
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Tunnelled
network
Access
router
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PPP + QoS
PPPoE
L2TP
Over
Dedicated link
IP
ATM

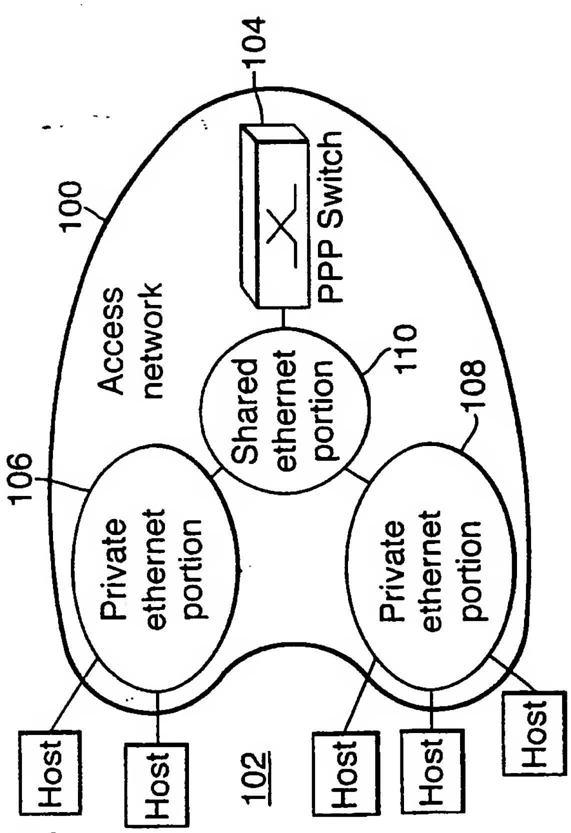
100
Access network
104
PPP Switch
106
Private ethernet portion
110
Shared ethernet portion
108
Private ethernet portion
Host
Host
102
Host
Host
Host

Fig.7.

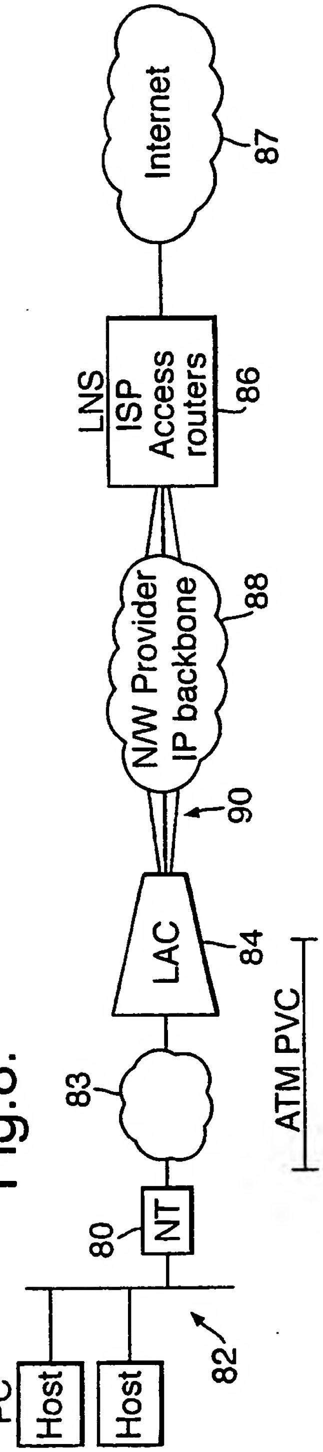
PC
Host
Host
82
80
NT
83
LAC
84
ATM PVC
90
N/W Provider IP backbone
88
LNS
ISP Access routers
86
Internet
87

Fig.8.